Designation: D2709 – 96 (Reapproved 2006)

Standard Test Method for Water and Sediment in Middle Distillate Fuels by Centrifuge[1]

This standard is issued under the fixed designation D2709; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the Department of Defense.

1. Scope

1.1 This test method covers the determination of the volume of free water and sediment in middle distillate fuels having viscosities at 40°C (104°F) in the range of 1.0 to 4.1 mm^2/s (1.0 to 4.1 cSt) and densities in the range of 770 to 900 kg/m^3.

NOTE 1—Fuels corresponding to Specification D975 Grades 1D and 2D, Specification D2880 Grades 0-GT, 1-GT and 2-GT, and Specification D3699 Grades 1-K and 2-K will usually fall in this viscosity and density range. Test Method D1796 is intended for higher viscosity fuel oils.

1.2 The values stated in SI units are to be regarded as standard. The values given in parentheses are for information only.

1.3 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D396 Specification for Fuel Oils
D975 Specification for Diesel Fuel Oils
D1796 Test Method for Water and Sediment in Fuel Oils by the Centrifuge Method (Laboratory Procedure)
D2880 Specification for Gas Turbine Fuel Oils
D3699 Specification for Kerosine
D4057 Practice for Manual Sampling of Petroleum and Petroleum Products

3. Terminology

3.1 *Definitions of Terms Specific to This Standard:*

3.1.1 *distillate fuel*—a virgin or cracked or blend of virgin and cracked distillate having a flash point greater than 38°C.

4. Summary of Test Method

4.1 A 100-mL sample of the undiluted fuel is centrifuged at a relative centrifugal force of 800 for 10 min at 21 to 32°C (70 to 90°F) in a centrifuge tube readable to 0.005 mL and measurable to 0.01 mL. After centrifugation, the volume of water and sediment which has settled into the tip of the centrifuge tube is read to the nearest 0.005 mL and reported as the volumetric percent water and sediment by centrifuge.

5. Significance and Use

5.1 This test method is used as an indication of water and sediment in middle distillate fuels such as Grade Nos. 1 and 2 fuel oil (Specification D396), Nos. 1-D and 2-D diesel fuel (Specification D975), and Nos. 0-GT, 1-GT, and 2-GT gas turbine fuels (Specification D2880).

5.2 Appreciable amounts of water and sediment in a fuel oil tend to cause fouling of the fuel-handling facilities and to give trouble in the fuel system of a burner or engine. An accumulation of sediment in storage tanks and on filter screens can obstruct the flow of oil from the tank to the combustor. Water in middle distillate fuels can cause corrosion of tanks and equipment, and if detergent is present, the water can cause emulsions or a hazy appearance. Water is necessary to support microbiological growth at fuel water-interfaces in fuel systems.

6. Apparatus

6.1 *Centrifuge*, capable of whirling two or more filled centrifuge tubes at a speed which can be controlled to give a relative centrifugal force (rcf) of 800 ± 60 at the tip of the tubes. The revolving head, trunnion rings, and trunnion cups, including the cushions, are to be soundly constructed to withstand the maximum centrifugal force capable of being delivered by the power source. The trunnion cups and cushions shall support the tubes when the centrifuge is in motion. The

[1] This test method is under the jurisdiction of ASTM Committee D02 on Petroleum Products and Lubricants and is the direct responsibility of Subcommittee D02.14 on Stability and Cleanliness of Liquid Fuels.

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[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

TABLE 1 Rotation Speeds Applicable for Centrifuges of Various Diameters of Swing

Diameters of Swing[A]		Rpm at 500 rcf	Rpm at 800 rcf
in.	cm		
12	30.5	1710	2160
13	33.0	1650	2080
14	35.6	1590	2000
15	38.1	1530	1930
16	40.6	1480	1870
17	43.2	1440	1820
18	45.7	1400	1770
19	48.3	1360	1720
20	50.8	1330	1680
21	53.3	1300	1640
22	55.9	1270	1600
23	58.4	1240	1560
24	61.0	1210	1530

[A] Measured between tips of opposite tubes when in rotating position.

centrifuge shall be enclosed by a metal shield or case strong enough to eliminate danger if any breakage occurs.

6.2 The data in Table 1 can be used to determine the centrifuge speed setting required for the centrifuge to meet relative centrifugal force requirements for this method and was developed using the following equations:

$$\text{rpm} = 265\sqrt{\text{rcf}/d} \quad (1)$$

where:
rcf = relative centrifugal force, and
d = diameter of swing, in inches, measured between tips of opposite tubes when in rotating position or

$$\text{rpm} = 422\sqrt{\text{rcf}/d} \quad (2)$$

where:
rcf = relative centrifugal force, and
d = diameter of swing, in centimetres, measured between tips of opposite tubes when in rotating position.

6.3 *Centrifuge Tube*, cone-shaped, 100-mL with capillary tip capable of measuring 0.01 mL and readable by estimation to 0.005 %.

6.4 *Centrifuge Tube*, pear-shaped, 100-mL, with tube tip having graduations of 0.01 mL over the range 0 to 0.2 mL.

7. Sampling

7.1 Sampling shall be consistent with the procedures of Practice D4057.

7.2 The sample for a laboratory test will normally be an aliquot of a much larger sample taken for full or partial specification testing. The full sample should have been taken by a procedure consistent with Practice D4057. Allow the sample container and its content to equilbrate between 21 to 32°C (70 to 90°F). In general, the chosen laboratory test temperature should not be lower than that at which the fuel is stored or used as too low a temperature may cause free water haze to form from additional free water formation.

8. Procedure

8.1 *Temperature Control*—After the sample container and its contents have equilibrated to laboratory temperature, between 21 to 32°C (70 to 90°F), agitate the full sample by hand or preferably by a mechanical shaker for 10 min to ensure homogeneity. (**Warning—**Flammable.)

8.2 As soon as possible, to prevent losing any water or sediment, fill the centrifuge tube to the 100-mL mark directly from the sample container. Stopper and place in a trunnion cup opposite another filled tube to establish a balanced condition, and whirl 10 min at a speed sufficient to produce a relative centrifugal force (rcf) of 800 ± 60 at the tip of the whirling tubes. (For the relationship between diameter of swings, rcf, and rpm, see Table 1.) Record the combined water and sediment at the bottom of the tube to the nearest 0.005 mL.

9. Report

9.1 Report the volume of the combined water and sediment read from the tube as the percentage of the total sample, since a 100-mL sample was used. Report results lower than 0.005 % as either 0 or 0.005 volume %.

10. Precision and Bias [3,4]

10.1 *Precision*—The precision of the procedure in this test method, for measuring the volume percent amount of combined water and sediment in middle distillate fuels by centrifuge was determined by a round robin test program performed by 6 individuals using 13 samples at a common site.

10.1.1 *Repeatability*—The difference between successive measured volume percent amounts of combined water and sediment obtained by the same operator using the same centrifuge and type of pear shaped tube under constant operating conditions on identical distillate fuel samples at the same site would, in the long run and in the normal and correct operation of the test method, exceed 0.014 volume % in 1 case in 20.

10.1.2 *Reproducibility*—The difference between two single independent measurements of volume percent amounts of combined water and sediment obtained by different operator/centrifuge pairs using the same type of pear shaped tube on identical distillate fuel samples at the same site would, in the long run, in the normal and correct operation of the test method, exceed 0.041 volume % in 1 case in 20.

10.2 *Bias*—Since there is no accepted reference material suitable for determining the bias for this procedure for measuring water, the bias is not available for this test method.

11. Keywords

11.1 centrifuge; centrifuge tube; distillate fuel; water and sediment

[3] Precision data for this test used pear-shaped tubes.

[4] Supporting data have been filed at ASTM International Headquarters and may be obtained by requesting Research Report D02-1308.